PCT / SE 2004 / 000062

PRV

PATENT- OCH REGISTRERINGSVERKET
Patentavdelningen

REC'D 09 FEB 2004
WIPO PCT

Intyg
Certificate

Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.

REGISTRERINGSVERKET • PATENT

(71) Sökande Imego AB, Göteborg SE
Applicant (s)

(21) Patentansökningsnummer 0300127-8
Patent application number

(86) Ingivningsdatum 2003-01-17
Date of filing

Stockholm, 2004-01-28

För Patent- och registreringsverket
For the Patent- and Registration Office

Sonia André

Sonia André

Avgift
Fee

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

BEST AVAILABLE COPY

PATENT- OCH REGISTRERINGSVERKET
SWEDEN

Postadress/Adress: Box 5055, S-102 42 STOCKHOLM
Telefon/Phone: +46 8 782 25 00, Vx 08-782 25 00
Telex: 17978, PATOREG S
Telefax: +46 8 666 02 86, 08-666 02 86

Title

INDICATOR ARRANGEMENT

TECHNICAL AREA

The present invention relates to a system and method for determining characteristics of a body and especially the linear and/or angular velocities of a substantially cylindrical rotating body using objects attached to the body, or placed within the body.

DESCRIPTION OF STATE OF THE ART

Cylinder shaped bodies, e.g. tyres and other structures, which are manufactured of rubber, synthetic or organic material or the like, are deformed because of the contact with another surfaces. Moreover, the characteristics and functions of different structures are deteriorated in course of time.

Different methods and devices have suggested for detection of deformation, e.g.: WO 00/02741 discloses a method and an apparatus for counting the revolutions of a pneumatic tyre utilizing a sensor, which responds to the periodic mechanical stresses when the tyre rotates under load on a load-bearing surface such as a roadway. The sensor can be constituted of a piezo-element, electrically connected to a revolution counting module. The piezo-element is suitably attached to or embedded within the inner wall of the tyre, under the tread or the side wall, in a way which causes it to flex with the tyre each time the circumferential sector of the tyre containing the piezo-element is compressed against the road or another vehicle supporting surface.

US 6,105,423 discloses a sensor comprising a piezo-electric bar for detecting rotations of a pneumatic tyre on a vehicle. The piezo-electric bar is effectively fixed at its two ends, which ends are also attached to two spaced apart points on the inner surface of the tyre tread by means of adhesive. The centre of the piezo electric bar is attached to the centre of the base, and then to the inner surface of the tyre, at a point midway between said end points of the bar. Thus, when the tyre tread is flattened in the contact patch from its normal curved shape, the centre of the bar is radially moved inwards with respect to the fixed point at its ends. An electrical circuit block processes the signal so that an output pulse is produced only for radially inward movement of the contact point.

US 4,862,486 discloses an apparatus comprising a piezoelectric polymer sensor, which senses a change in stress when a given section of the tyre is stressed with each revolution. The piezoelectric polymers are comprised of aligned dipoles acting to apply and release stresses on the piezoelectric polymer sensor when stressing the tyre. The apparatus is mounted to the inner sidewall of the tyre.

JP 04254730 A discloses a device for monitoring tyre air pressure, which allows the tyre pressure to be detected constantly while an ambient environment of the tyre is stable against fluctuation. The device comprises a piezo-electric element, of which the impedance changes according to an air pressure of a tyre, and a rim-side coil is changed by a fluctuation of an ambient environment of the tyre as well.

US 5,546,070 discloses the use of a piezo ceramic element simultaneously as a sensor and also as an energy source for a capacitor to supply a transmission unit.

DE 197 45 734 A1 shows a sensor for detecting and registering the wear and the tread of a tyre. The tyre comprises single elements, however, which are not dispersed. In FR 2645799 a magnetic mass is arranged at a specified depth of the tyre, and consequently, can be supervised.

US 5,559,437 relates to methods and apparatus for checking the condition of worn tyres, e.g. before recapping, for the non-destructive verification of the condition of a metallic reinforcement element of worn tyres. US 6,005,388 relates to methods for detecting defects in tyres.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an arrangement for determining the condition of a substantially cylindrical resilient (deformable) body, particularly a rotateble body or structure. The condition comprises mainly the deformation of the material.

Preferably, the substantially cylindrical resilient rotating body is a tyre, or a part thereof, and the arrangement is used for example, to determine the movement, e.g. revolution, which aids to determine velocity of a vehicle, the skid characteristics, the air pressure, etc.

Yet, another object of the present invention is to provide an arrangement for determining the condition of a substantially cylindrical rotating body in an apparatus and an associated structure, and the combination thereof as well. Preferably, in this case the cylindrical rotating body can be a roll or a cylinder for feeding a sheet material, such as paper. Here, the arrangement is used for e.g. determining the movement and presence of the material, rotation speed, sliding characteristics.

Moreover, using indicators comprising a piezo-electric plastic material, according to one aspect of the invention, gives certain advantages such as possibility for having larger detector elements. Moreover, the piezo-electric plastic material is less expensive than piezo-electric ceramic material. Furthermore, the piezo-electric plastic material can provide larger tensions and effects than the piezo-electric ceramic material as well. Yet, the two main advantages are the anisotropic characteristics of a piezo-elastic plastic material being utilized in the invention and the non-brittleness (plasticity).

However, the invention can also be provided with additional types of indicators in form of a magnetic material being dispersed and disintegrated in the tyre part, or a magneto-elastic material in form of thin foils or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described with reference to the embodiments illustrated in enclosed drawings, in which:

Fig. 1a is a schematic cross-sectional view of a first application employing a device according to the invention,

Fig. 1b is a schematic frontal view of the first application employing a device according to the invention,

Fig. 2 is a cross-sectional view of a second application employing a device according to a second aspect of the invention,

Fig. 3 is a schematic cross-sectional view of a third application employing a device according to the third aspect of the invention,

Fig. 4a is a schematic side view of an arrangement comprising a device according to a fourth embodiment of the invention,

Fig. 4b is frontal view of the arrangement according to Fig. 4a,

Fig. 5a is a schematic side view of an arrangement using a device according to a

fifth embodiment of the invention, and

Fig. 5b is a schematic side view of an arrangement according to a sixth embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

To sum up the invention, all exemplary embodiments described in the following, may be made of different materials, for example:

- Piezoelectric material, which generate charge upon deformation. The charge can be transferred into a signal (voltage and/or current). The signal can be detected by external means (electric antennae) or it may drive a low power amplifier, which enhances the signal. This amplifier can be placed within the body itself. An external device can detect the amplified signal.
- Magnetic material (permanently magnetic), e.g. a strip or magnetic particles.
- Magneto-elastic material, which becomes magnetic upon deformation. When the deformed material returns to its non-deformed state the magnetism disappears. A magnetic antenna, for example suitable coils, can detect the magnetic material.

In the first application, a substantially cylindrical rotating body 13 is schematically shown in Figs. 1a and 1b. In this case, the body 13 comprises a wheel 10 of a vehicle 12, comprising the tyre 13. A number of indicators 111, for example six, are arranged on/in the tyre 13 or embodied into the tyre material. The tyre 13 is of a conventional type and made of an organic, resilient, elastic, rubberised material. The indicators 111 can preferably be arranged inside the metallic reinforcement or on the surface of the tyre 13.

In Fig. 1b, each indicator 111 is strip-shaped and arranged substantially in the axial direction of the tyre 13, but may also extend in the radial direction (Fig. 1a). However, in a second application according to Fig. 2, another type of indicator 112 is arranged in the longitudinal, peripheral direction of the tyre 13.

The indicators 111 and 112 consist of a piezo-electrical polymer material or of a magnetoelastic material. During the rotation of the tyre, as a result of the contact between the tyre 13 and the ground, the tyre 13 is locally elongated, particularly in the contact zone between the tyre 13 and the ground. Thus, an elongation of the tyre 13 results in an elongation of the indicator element in close proximity of the

part of the tyre that has contact with the ground and generation of a signal. After a short while, the element relaxes back to its original shape and signal is zeroed. Then the next strip is deformed and so on. Typically, the speed of about 100 km/h, and a wheel with radius of about 0.5m (at the place of the strip) and provided with six strips gives a frequency of about 1 kHz.

The signals can be generated when both sides of the elongated indicator 111 are short-circuited by means of an appropriate resistance (not shown). For instance, at least one energy source (not shown) can be used in the electrical circuit for generating useful energy, e.g. for amplifying the signal of the indicator 111, or even for supplying other components. Preferably, said energy source is a capacitor.

A magnetic detection is also possible, e.g. by creating a magnetic path formed as an appropriate coil on the tyre, which can be used for generating a pulsed magnetic field, which e.g. can be detected by an antenna arranged in connection with the vehicle body. The signal receiver is an important part of such an antenna, which can be arranged as another coil being charged when a magnetic field is generated by the coil in the tyre 13. Additionally, this arrangement can be arranged inside the metal reinforcement in the tyre 13 as well.

Another possibility is to use a magnetoelastic material, which acts very similarly to piezoelectric material. It magnetizes when deformed and demagnetises when the deformation relaxes to equilibrium. Again, in this case an appropriate magnetic detection on the body of the vehicle should be used.

However, on the contrary, the indicator 112 in the second embodiment as shown in Fig. 2, elongates during the time the part of the tyre that contains the indicator has contact with the ground. During that time interval, an electric signal is created. The linear velocity of rotation can be obtained if the length of the strip is known simply by dividing this length by the duration of the voltage/current pulse.

Additional information is provided by the frequency at which the pulses occur due to the rotation of the vehicle. Both are related to each other and to the linear velocity of tyre motion. The difference in linear velocity of the tyre calculated from the pulse duration and from the frequency of tyre rotation (which is proportional to the angular speed of tyre rotation from which linear velocity of tyre motion can be calculated assuming certain tyre diameter, for example the diameter the tyre has at

an appropriate air pressure) using appropriate software should be constant. When the difference is not constant but varies in time it signals that the skid did take place.

Yet another way to determine whether the skid occurred, or not, is to compare the readings (frequency or the time interval) obtained from the arrangements placed on other wheels to each other. The sensor readings give identical velocities of each of the wheels when the movement with no-skid takes place. When the skid takes place the readings obtained from the skidding wheel(s) will differ from the reading obtained from the non-skidding wheel(s).

In addition, small and slowly varying difference signals that the air pressure is not correct since this changes the tyre diameter and thus the difference in the linear velocity determined by each of the methods, respectively.

In the third embodiment of the invention, the indicator 14 is arranged inside the tyre material, see Fig. 3. In this case, the indicator 14 is made of a magnetic material, which is dispersed and disintegrated in the material of the tyre 13, and preferably arranged, in a top layer of the tyre 13. The magnetic indicators 14 are arranged spaced apart (distance 15) inside the material of the tyre 13. As the tyre 13 wears out results are: (1) the amount of the magnetic material decreases, and (2) the distance between the tyre 13 and a preferred detector means, which detector means is to be explained in the following.

In all aforementioned embodiments, one or several detector means 16 for detecting the indicators 111, 112 and 14 are arranged and generate a signal. Preferably, the detectors 16 are arranged inside a wheel housing in a conventional vehicle close to the tyre 13. Advantageously, two detectors 16 are arranged on each side of the tyre 13 to be measured, and at a specified distance from each other.

Thus, the arrangement 10 according the first and the second embodiment of the invention is used for indicating movement. In addition, the atmospheric pressure can also be measured, since the indicator 112 is elongated the tyre 13 is deformed due to air pressure.

Note however that using only a radially placed strip as in Fig. 1a or only a longitudinally placed strip as in Figs. 2 or 3 does not allow one to determine a slow

pressure reduction in the tyre during normal use since both the piezoelectric and the elastomagnetic materials are not sensitive to slow deformation rates.

In the second embodiment, the velocity is obtained by indicating the time intervals between the indicators 112, contacting the ground and the length of the strip-shaped indicators 112.

Furthermore, for obtaining the spin characteristics of the vehicle wheel, it is also possible to compare the axial frequency of the wheel to the frequency of the ground contact. If these frequencies are different, spinning may occur.

In the third embodiment the material characteristics are indicated, principally the amount of the magnetic material in the tyre 13. The signal intensity strength declines as the amount of the magnetic material 14 decreases and the distance between the tyre 13 and the detector means 16 increases, whereby the wear can be determined.

Clearly, in above-mentioned examples, the wheel can be substituted with any rotating structure.

In the following, the arrangements 20 and 30 according to additional embodiments of the invention for determining the condition and the characteristics of a material are described in conjugation with schematical Figs. 4 – 5b, which relate to application of a sheet material production such as paper. In the embodiments, the condition and the characteristics mainly refer to the presence of material and the movement as well.

The arrangements 20 and 30 comprise at least one substantially cylindrical rotating body, which in the following denoted rolls 23 and 33. Structures 22 and 32 are arranged to cooperate/interact with the rolls 23 and 33. In this case, the structure 22 and 32 can be a wire, belt, paper sheet, banknotes, paper money or the like. Furthermore, the structures 22 and 32 are arranged adjacent to the rolls 23 and 33; however, in some cases the structures 22 and 32 can partially or completely be arranged at least partly in contact with the rolls 23 and 33.

In Fig. 4a, the belt 22 extends between three rolls 23. Indicators 211 and 212 are arranged inside the material of the belt 22, as shown in an lateral view in Fig. 4b. In

this case, the indicators 211 and 212 are woven into the belt 22, either in the longitudinal direction of the belt 22, and/or in the transverse direction of it. The indicators 211 and 212 may consist of wires of a piezo-electrical polymeric material or of a magnetoelastic material (which may or may not be covered by a suitable polymer). Moreover, at least one detector 416 can be arranged in connection with the indicators 211 and 212 and the paper making machine.

During the operation of the paper making machine, the indicators 211 and 211 are subjected to additional compression and elongation as the belt 22 passes the rolls 23. If the indicators 211 are arranged in the transverse direction of the belt 22, the frequency of the obtained pulses is measured when the indicators 211 is subjected to an additional tension. The frequency is proportional to the velocity, and the velocity of the roll 21 can easily be calculated by means of appropriate software. Alternatively, if the indicator 212 is arranged in the longitudinal direction, the absolute linear rotation speed of the rolls 23 is measured in substantially the same way as described above in connection with tyres, and subsequently converted to a frequency, which is then compared to the frequency of the belt 22.

Thus, the speed of the belt 22, which should be constant, can be measured for ensuring that it does not slide on the rolls 23. The speed of the belt 22 can also be measured in relation to the rotation speed of the rolls 23. In this way it is possible to detect if the belt 22 slides on the rolls 23, which in turn indicates that the belt 22 is exhausted, probably due to its elongation, and should be replaced.

In this embodiment, it is also possible to use magnetic particles as an alternative to the piezo-electrical polymeric material. The magnetic particles are woven into the transverse or longitudinal threads in the same way as described above. Consequently, the primary signal is not an electrical pulse but a magnetic field pulse. Magnetic field pulses can be detected by means of, e.g., a hall-sensor or a coil. Furthermore, a pulsed magnetic field results in current pulses in the coil. It is also possible to use a substantially magneto-elastic material in the threads; whereby an elastic deformation of the threads will give rise to a magnetic field.

Naturally, this embodiment can also be used in other applications involving stretching a material, such as a cloth or a fabric, wherein the movement can be controlled by means of rolls.

In a fifth embodiment, which is shown in Fig. 5a, two rolls 33 are preferably arranged in a printer application 20 for feeding paper sheets (or other information carrier). At least one indicator 331 is arranged on the surface of the printing paper, or substantially within the printer paper 32. In the preferred embodiment, the indicator 331 comprises a foil integrated substantially inside the paper 32. At least one detector 516 can be arranged to detect the presence of the indicators.

In this case, the movement is indicated in form of, e.g. interruptions in the printer, which are possible to predict if the velocity of a paper moving through the printer rolls and the velocity of the printer rolls are known.

Yet another preferred embodiment in form of a banking paper application for the feeding of bank notes, paper money or the like is shown in Fig. 5b, which is principally designed as the printing application described above. The difference is that at least one indicator 312 is arranged as a strip. Preferably, several indicators 312 constitute a bar-code in the banking paper or paper money 32.

In the latter applications, the bank notes and paper money pass between the rolls 33, which read the frequency of the pulses generated because of the indicators. Then, the frequency is determined by means of the distance between the indicators 312 and the speed with which the feeding arrangement, i.e. the rolls 33, feed the banknote(s). If the bank notes or the paper money are forgeries, the indicators may not be present or the distances between the bar codes 312 will vary, which causes change of the frequencies. Thus, in this case a presence (existence/availability) of material in form of indicators 312 is indicated, and not the movement characteristics.

As mentioned, it is also possible to replace the piezo-electrical polymer material with magneto elastic material in all the embodiments mentioned above. Then the indicators should preferably be shaped as thin foils. An elongation or a compression of the foil causes a local magnetization, which fades away when the material retains to its original shape.

Thus, in the first mentioned embodiment, the body 13 can be comprise of complete or parts of tyres arranged, rolls, rollers, cylinders, delivery bowls, rubber-covered cylinders, drums, hole cylinders, etcetera in other applications such as conventional rolls in all types of machines, e.g. paper making machines, printers, banking paper

applications for bank notes and paper money including rolls, and arrangements of rubberised materials in general in other embodiments of the invention.

The indicators 111, 112, 14, 211, 212, 311 and 312 can comprise a strip-shaped band, a foil, a thread, a particle or the like. Furthermore, the detector means 16 is preferably constituted of coils, transponders or the like. Finally, it is also possible to put indicators 111, 112, 211, 212, 311 and 312 perpendicular to each other for obtaining an absolute velocity, i.e. independent or the radius of the substantially cylindrical body 13, 23, 33.

The invention is not limited to the shown embodiments but can be varied in a number of ways, e.g. through combination of two or more embodiments shown, without departing from the scope of the appended claims and the arrangement and the method can be implemented in various ways depending on application, functional units, needs and requirements, etc.

CLAIMS

1. A system for detecting characteristics of an elastic structure (13, 22, 23, 32, 33), said structure being provided with at least one indicator (111, 111, 14, 211, 212, 311, 312) and said system comprising at least one detector (16, 416, 516), characterised in
that said indicator comprises a deformable member, which upon deformation generates a signal convertible to a signal representing said characteristic.

2. The system of claim 1, wherein said structure is a substantially cylindrical rotating structure.

3. The system of claim 1, wherein said indicator is arranged on or inside said structure (13).

4. The system of claim 1, wherein said structure (13) is made of a non-conducting organic material.

5. The system of claim 1, wherein the indicator (111) is arranged in longitudinal direction of the structure (13).

6. The system of claim 1, wherein the indicator (112) is arranged in a radial direction of the structure (13).

7. The system of claim 1, wherein the indicator (211, 212, 311, 312) is transversely or longitudinally arranged in a structure (22, 32).

8. The system of any of preceding claims, wherein said indicator is at least one of a piezoelectric material, magnetic material or magneto-elastic material.

9. The system of claim 5, wherein the indicator is arranged to provide absolute linear velocity of the structure.

10. The system of claim 5 and 6, wherein the indicator is arranged to provide skid characteristics.

11. The system of claim 1, wherein said indicators (111, 112) consist of a piezo-

electrical polymer material and/or of a magnetoelastic material, said structure cylindrical shaped rolling on a surface and as a result of the contact between the structure (13) and said surface, the structure is locally elongated in a contact zone between the structure and the surface, whereby said elongation of the structure results in an elongation of the indicator in close proximity of the part of the structure that has contact with the surface and generation of a signal.

12. The system of claim 11, wherein said is generated when both sides of the elongated indicator (111) are short-circuited by means of an appropriate resistance.

13. The system of claim 1, using a magnetic detection by creating a magnetic path formed as an appropriate coil on the structure, which is used for generating a pulsed magnetic field, and detected by an antenna arranged in connection with the structure.

14. The system of claim 13, wherein said signal receiver is arranged as another coil being charged when a magnetic field is generated by said coil in said structure.

15. The system of claim 1, wherein said detector is a magnetoelastic material, which magnetizes when deformed and demagnetises when the deformation relaxes to equilibrium and said detector is a magnetic detection on the body of the vehicle should be used.

16. The system of claim 13, wherein the indicator elongates during a time period a part of the structure that contains the indicator is contact with the surface, whereby during that time interval, an electric signal is created, and a linear velocity of rotation is obtained if a length of the indicator is known by dividing this length by the duration of the voltage/current pulse.

17. The system of claim 13, wherein additional information is provided by a frequency at which pulses occur due to the rotation of the structure, both related to each other and to a linear velocity of the structure motion, and a difference in linear velocity of the structure calculated from the pulse duration and from the frequency of structure rotation varying in time indicates skid.

18. The system of claim 1, wherein the indicator (311, 312) constitutes a bar code in the structure (22, 32).

19. The system as claimed in any of the preceding claims, wherein the indicator (111, 112, 14, 211, 212, 311, 312) is shaped in form of a strip-shaped band, a foil, a thread, a particle or the like.

20. The system as claimed in any of the preceding claims, wherein the structure (13, 23, 33) comprises a tyre, a roll, a roller, a cylinder, a delivery bowl, rubber-covered cylinder, drum, or a hole cylinder.

21. The system as claimed in any of the preceding claims, wherein the structure (22, 32) is a wire, a fabric, a cloth, a printing paper, paper money, bank notes or the like.

22. A method of detecting characteristics of an elastic structure (13, 22, 23, 32, 33), the method comprising the steps of,
    - providing said structure with at least one indicator (111, 111, 14, 211, 212, 311, 312), said indicator comprising a deformable member, which upon deformation generates a signal convertible to a signal representing said characteristic, and
    - providing at least one detector (16, 416, 516) for detecting said signal.

23. The method of claim 22, wherein said characteristic is one of velocity and/or skid.

24. The method of claim 22, wherein said indicators (111, 112) consist of a piezo-electrical polymer material or of a magnetoelastic material.

25. The method of claim 23 wherein during the rotation of the structure on a surface and as a result of the contact between the structure (13) and said surface, the structure is locally elongated in a contact zone between the structure and the surface, whereby said elongation of the structure results in an elongation of the indicator in close proximity of the part of the structure that has contact with the surface and generation of a signal.

26. The method of claim 22, wherein said indicator is a magnetic device and a

magnetic path formed as an appropriate coil on the structure, which can be used for generating a pulsed magnetic field, which is detected by an antenna arranged in connection with the structure.

27. The method of claim 22, wherein a skid is determined by comparing readings in form of frequency or the time interval obtained from said indicators placed on other adjacent structures.

ABSTRACT

The present invention relates to a system and method for detecting the characteristics of an elastic structure (13, 22, 23, 32, 33), said structure being provided with at least one indicator (111, 111, 14, 211, 212, 311, 312) and said system comprising at least one detector (16, 416, 516). The indicator comprises a deformable member, which upon deformation generates a signal convertible to a signal representing said characteristic.

(Fig. 1a)

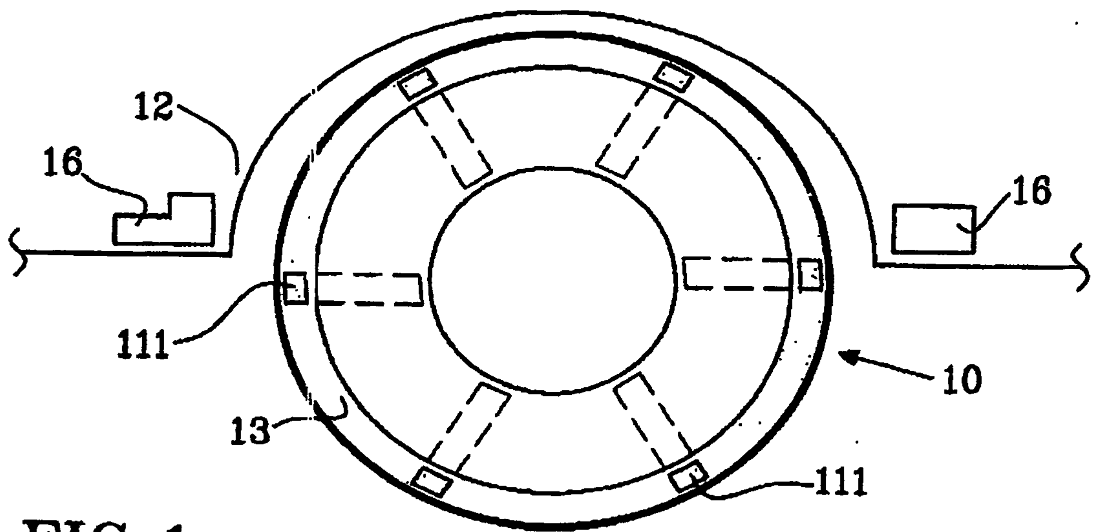

FIG.1a

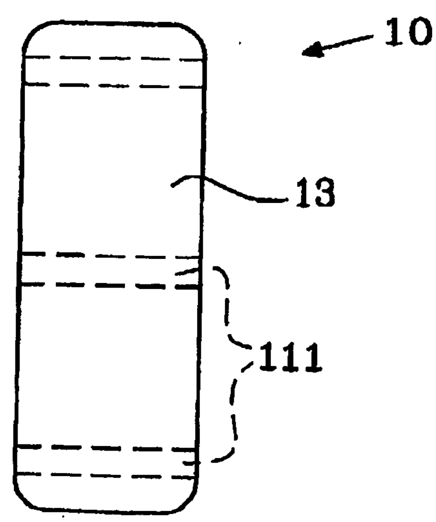

FIG.1b

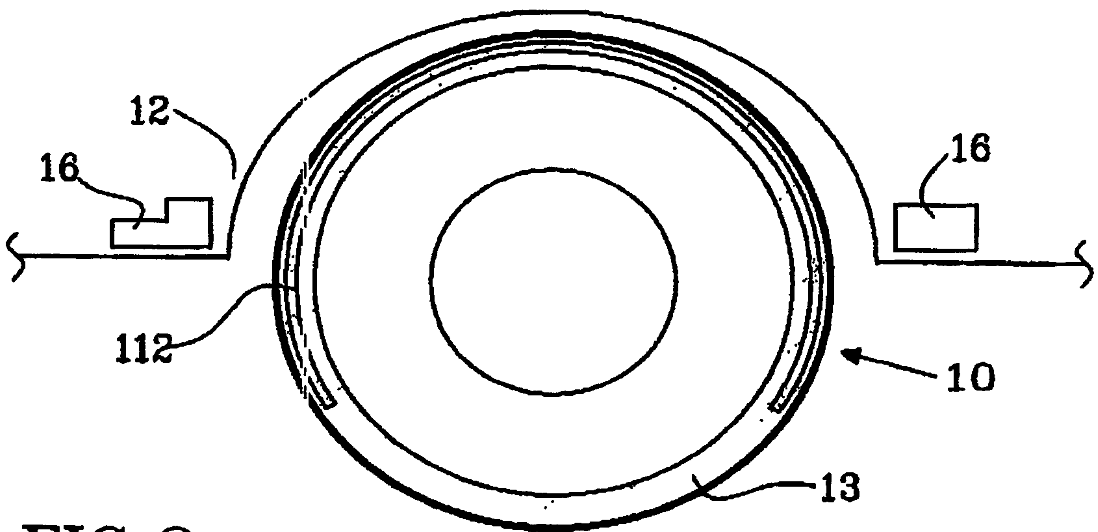

FIG.2

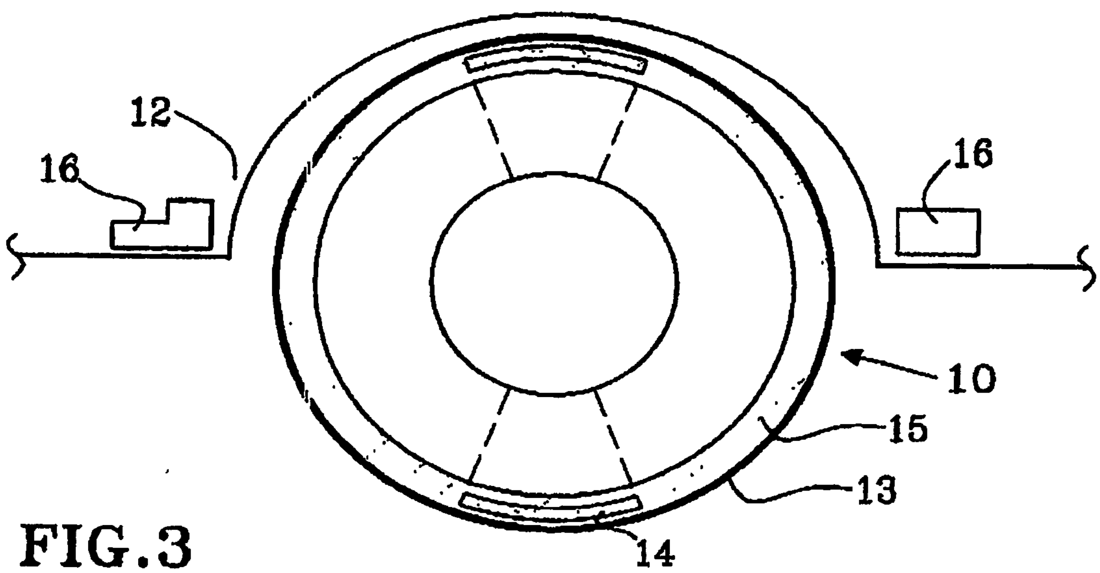

FIG.3

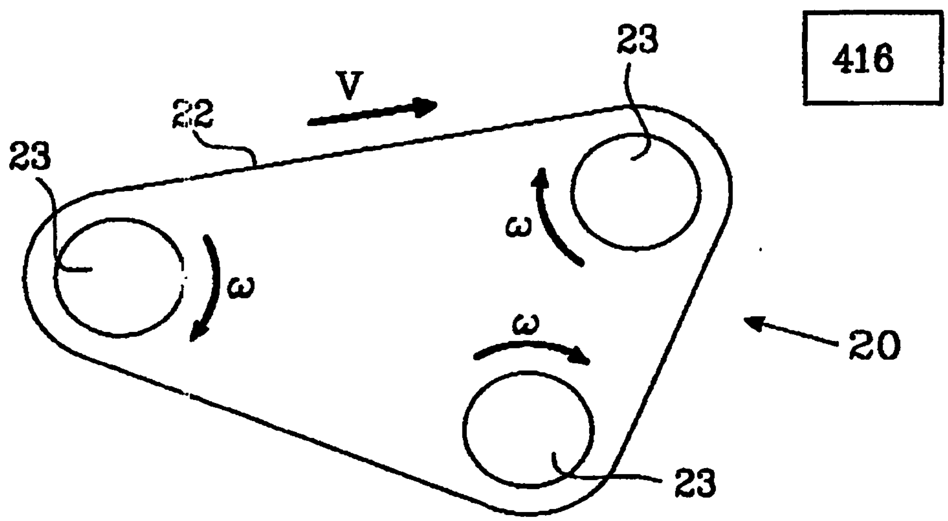

FIG.4a

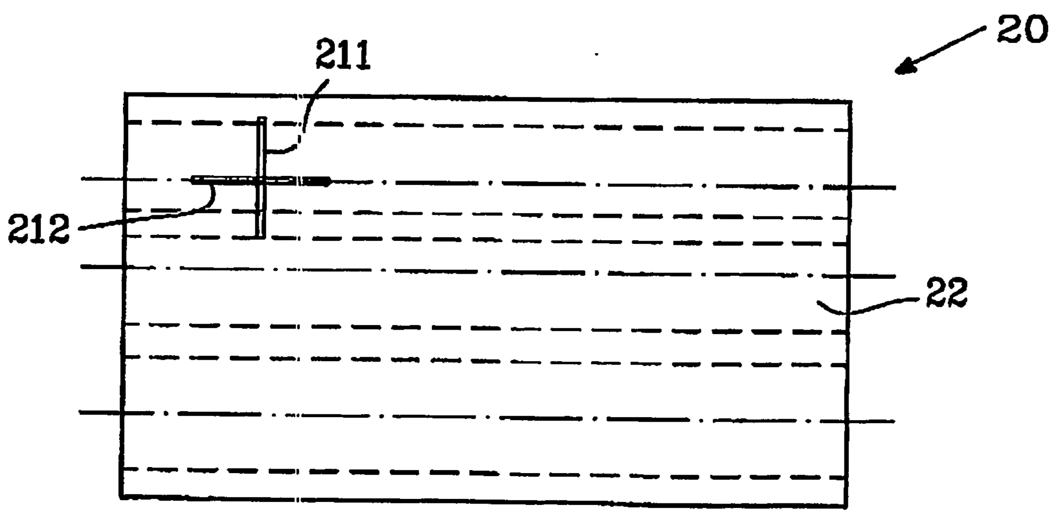

FIG.4b

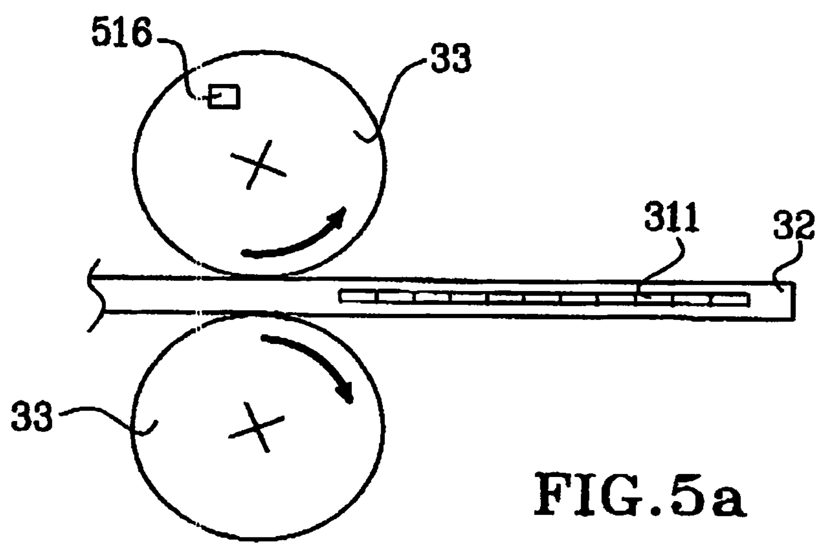

FIG.5a

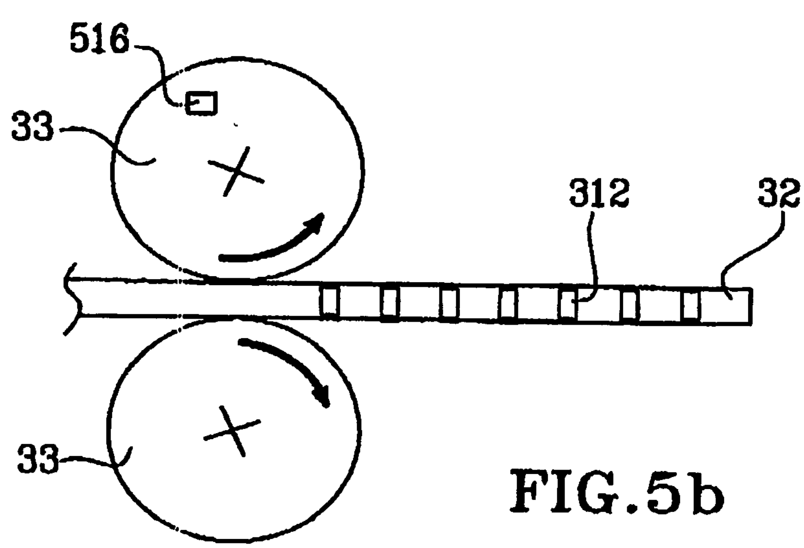

FIG.5b